NPS55-80-004PR

NAVAL POSTGRADUATE SCHOOL

Monterey, California

REPORT ON

AN EXPERIMENT ON FORMAL USE OF
HAND HELD PROGRAMMABLE CALCULATORS
IN STATISTICS COURSES

by

Donald R. Barr

January 1980

NAVAL POSTGRADUATE SCHOOL
MONTEREY, CALIFORNIA

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REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: NPS55-80-004PR	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE *(and Subtitle)*: Report on An Experiment on Formal Use of Hand Held Programmable Calculators in Statistics Courses	5. TYPE OF REPORT & PERIOD COVERED: Technical
6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s): Donald R. Barr	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Naval Postgraduate School, Monterey, CA 93940	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Postgraduate School, Monterey, CA 93940	12. REPORT DATE: January 1980
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS *(if different from Controlling Office)*	15. SECURITY CLASS. *(of this report)*: Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT *(of this Report)*

17. DISTRIBUTION STATEMENT *(of the abstract entered in Block 20, if different from Report)*

18. SUPPLEMENTARY NOTES

19. KEY WORDS *(Continue on reverse side if necessary and identify by block number)*

Hand Held Programmable Calculators
Instruction
Education
Experiment

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

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DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-014-6601

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ABSTRACT

A report is given of results of several "experiments," using exams of various design and questionnaires to determine the educational impact of formal use of hand held programmable calculators in certain classes. It is concluded that this approach has several advantages over traditional instruction.

1. Summary of Experiment and Results

During the period Sept '79 to Dec '79 an "experiment" was conducted to determine whether formal use of Hand Held Programmable Calculators (HHPC's) in certain classes can lead to more effective learning by students. The experiment was centered around a third quarter statistics course at NPS. It consisted of exams given "with" and "without" HHPC, exams on which students had choice of whether to use the HHPC, exams designed to test whether students would blindly plug data into inappropriate programs, questionnaires and instructor comments.

While this is not a definitive experiment in the sense of providing conclusions without possibility of effects of confounding factors or unexplained error sources, it does indicate a number of "reasonable" conclusions. Students are enthusiastic users of their HHPC's. They demonstrated confidence in their ability to solve routine applied statistics problems. They grew more optimistic about use of the HHPC's over a span of several quarters. They perceived a marked increase in their capabilities as a result of having HHPC's and indicated (with a few exceptions) they would purchase their own HHPC if the ones issued them at the beginning of their curriculum were recalled.

The author (who was the instructor of the experimentation course) believes formal use of HHPC's in statistics classes provides a very significant increase in the variety of topics, approaches and materials that can be used in the course. He believes use of HHPC's represents an extremely cost-effective innovation in education. Based in part on results of this experiment, the author concludes that providing HHPC's (with permanent retention by the student) would significantly upgrade the capabilities of the graduates of NPS.

2. The Experiment

Hand held programmable calculators (HHPC's) have been used in a formal organized manner in various classes at the Naval Postgraduate School (NPS) for several years. As a result of perceived successes in these ventures, there have been suggestions by faculty and administrative personnel here that HHPC's should be acquired by all (or nearly all) our students. Such acquisition might be through required purchase by the students (much in the manner of current practice with textbooks) or through distribution of school owned HHPC's to students on a loan (or perhaps permanent) basis. It is desirable to assess the impacts of such programs before making decisions about their implementation. Programs involving acquisition of HHPC's by large segments of our student body could affect many aspects of the educational process, ranging from costs for the student or institution to methods of evaluating student performance. In this report, we consider only one such aspect, through an attempt to determine the educational effectiveness of the HHPC.

It has generally been assumed by proponents of the idea of organized use of HHPC's in classes that such use will result in the enhancement of capabilities of students. The problem has been to devise a way to demonstrate such improvement. An experiment to evaluate the use of HHPC's was initiated by Dr. W. M. Woods, Dean of Educational Development at NPS. As part of this experiment, a Texas Instruments TI-59 calculator was issued to each member of an incoming group of students entering the Operations Research/Systems Analysis (OR/SA) curriculum at NPS. Assessments of the effects of having these calculators were to be made periodically during the eight quarter OR/SA course, and two years beyond these students' academic work at NPS.

I taught this group of students in the second and third quarters of their three-quarter probability and statistics

sequence. As part of the "HHPC experiment," an evaluation was to be made during the third quarter statistics course. I agreed to attempt to make evaluations of the effects of the HHPC's as part of the HHPC experiment, provided the students would in no way be penalized through their non-voluntary involvement in the experiments.

The problem was to devise a "non-obtrusive" method of evaluation which would not adversely affect the students' grades, knowledge gained, work level or attitude toward the subject matter. These constraints appeared to rule out many traditional experimental designs involving a treatment group (with HHPC's) and a control group (without HHPC's) which would be otherwise balanced with respect to major factors such as time, instructor, student abilities, student loads, and so on. Indeed, such constraints have made the measurement of effects of education methods in general a traditional problem, for which there are only indirect, round about "semi-solutions." I used an approach consisting of several "sub-experiments" involving exams and questionnaires administered to the students, in my attempt to answer the following questions:

- do students use their HHPC's?
- can students use their HHPC's?
- do students need to use their HHPC's?
- do students believe the HHPC's are useful?
- do students like to use the HHPC's?
- does the instructor believe the HHPC's are a useful tool for statistics education?

Before describing the sub-experiments used, I wish to point out some weaknesses of this approach. There is obvious confounding of the instructor effect with the HHPC effect, for the instructor chooses the specific course material (although not the topics to be covered), and the instructor makes up

the exams. In the present case, the instructor chose the experimentation approach and evaluated the results. It is possible these materials were slanted toward use of HHPC's. There is confounding of time effects with HHPC effects. In comparing performance on two exams where one was taken "with HHPC" and one "without HHPC," a difference might be due to time (i.e., the "with HHPC" exam was taken later, when the students were more experienced with the topic). Moreover, the students knew they were part of an experiment, so the Hawthorne effect is a possible contaminant of the experimentation results.

There were several sub-experiments, which are described briefly here. Results of these experiments are discussed in the following section, and conclusions and recommendations are given in the final section.

Sub-Experiment 1.

Similar exams, balanced with respect to computational content, were administered one week apart. In the initial week, half the students had exam 1, the other half had exam 2, and the students did not have prepared programs (although they had their calculators in their possession). The exams were over material that had been previously covered in the course. In the subsequent week, prepared programs were issued to the students for the purpose of solving problems of the type on the exams (testing hypotheses). Then (after a few days to allow familiarization) the exams were issued again, with each student receiving an exam different from that he used in the initial week. The students did not know at this time that this was part of an experiment. This experiment compares student performance before and after prepared programs were issued, with balance over exams and students. There is confounding of the HHPC effect with time effects, as noted above.

Sub-Experiment 2.

A single exam (over the topic of regression) was administered, after students had been issued prepared programs for their TI-59's. Students were given a choice of whether to use their calculators with programs or to use them only in a manual calculation mode. They were assured that each group would be graded separately, so that grades would be balanced between the groups. The goal was to determine whether students would choose the HHPC when a viable alternative was available; another goal, of course, was to evaluate how well each group would do, although no comparison should be made between the group scores. The students knew this was part of the HHPC experiment. The fact that students volunteered for the group they wished to be in would tend to put the skillful HHPC user in the HHPC group, so the two groups are not balanced. This approach does avoid punishing the student, as far as grades are concerned, and it does give information with respect to student confidence in the HHPC.

Sub-Experiment 3.

Students were given a quiz (on Bayes formula) over material they had studied two quarters previously, at which time they had been given a prepared program for solving such problems, and practice using it. The object was to determine whether students would use a program they had studied sometime previously, whether they would force the data into an inappropriate program currently being studied (in a mechancial "stuff the data into a black box" fashion) or whether they would solve the problem using their calculators only in a manual calculation mode.

Sub-Experiment 4.

For the final exam, students were given two choices: a "non-computational" exam or a "computational" exam. These exams were designed to be of about equal difficulty (in the instructor's opinion), and were written before the course started. The object of this experiment was to determine the student's willingness to use the HHPC (and their confidence in it), if they are given a choice. Since parts of the exams were identical, it also gives an opportunity to determine what types of students tend to take the computational option, where their HHPC's would be used (presumably with the prepared programs) to solve the exam problems. The differences between this sub-experiment and Sub-experiment 2 are that here students were informed of the choice to be available to them several days in advance (for sub-experiment 2 it was an "on the spot" decision), and here there were two separate exams (for sub-experiment 2 there was only one exam).

Sub-Experiment 5.

A questionnaire, developed by Dr. G. Semb, was administered at the end of the course. The same questionnaire had been administered to these students at the end of their first quarter. Responses and individual changes in responses were analyzed to determine student opinions and patterns of opinion changes with respect to use of HHPC's in statistics courses.

Sub-Experiment 6.

Comments and observations were entered in his class notes by the instructor throughout the quarter. These observations and opinions are summarized and presented here. This is not really an experiment, but rather an expression of opinion from a somewhat biased source.

3. Results and Conclusions

Summaries of results for each sub-experiment are as follows:

Sub-experiment 1 (exams given before- and after- issue of prepared programs). Four students (out of 25) scored lower on the second "with programs" exams. Many of the remaining students made impressive gains on the "with program" exam over their scores on the "without program" exams. Mean scores (out of possible 10 for a perfect performance) were: 4.4 without, and 7.8 with programs. The difference is statistically significant at a level below 10^{-4} (highly significant, with a paired t-test).

Conclusion: A vast majority of students were able to solve routine test of hypothesis problems significantly better with the aid of prepared calculator programs.

Sub-experiment 2 (single exam with student choice of whether to use HHPC with prepared programs). Only three of the 25 students chose not to use the HHPC with prepared programs. Two of the these were among the best students in the class. All students did well on this exam.

Conclusion: Most students have confidence in their ability to use the HHPC in programmed mode to solve regression problems; they are indeed able to do so, with very few errors.

Sub-experiment 3 (quiz over material covered in an earlier course). No student used the previously prepared (and exercised) program to solve this Bayes formula problem although most (17 of the 25) students recognized it to be such a problem. (Of the 8 students apparently not recognizing the nature of this problem, 5 received final grades below the class median). On the other hand, no student attempted to plug the data into an inappropriate program. Instead, those students

who made computations for their solutions either used their HHPC in a manual mode (19 of 25) or did hand computations (3 of 25). It is interesting to compare the mean score for this group (7.6 out of 10) with the mean score for a group of management students given the same exam immediately after extensive practice with use of the prepared program with their TI-59's (10 out of 10).

Conclusion: Students are not inclined to plug data blindly into an inappropriate program; neither do they retain previously exercised programs in a ready-to-use private library of programs.

Sub-experiment 4 (student choice between a computational exam and a non-computational exam). Only two students chose the non-computational exam. Both of these students were among the top students of the class, and both had chosen the non-HHPC option in sub-experiment 2. Even so, the difference in mean scores between the two groups is not significant at the $\alpha = .05$ level (t-test).

Conclusion: Again, students demonstrated confidence in their ability to use the HHPC's with prepared programs to solve applied statistics problems. A small minority of the better students prefer "theoretical" to "computational" exams.

Sub-experiment 5 (questionnaire). A tabulation of responses on the questionnaire adminstered at the end of the course, together with changes from responses on the same questionnaire administered to these students six months earlier, is shown in the Appendix. (Note that on questions with numerical answers, smaller numbers reflect more optimistic

responses in every case except item 7. Note that several of the items (1, 2, 3, 4, 5, 7, 9, 10, 11, 12) are related to the HHPC concept, whereas the remaining items concern the specific hardware, software and course materials used for this particular course.) The conclusions that follow concern three aspects of the opinions received on these questionnaires: current attitudes as expressed by mean numerical scores, changes in attitude from the earlier questionnaire and individual changes and attitudes (for 16 individuals with responses that could be matched in terms of early and current questionnaires).

Conclusions. Students were optimistic about use of HHPC's in PS 3303. They felt it helped not only in terms of computation (item 3) but also in terms of success in the course (item 1) and, to a lesser extent, in understanding the material (item 4). Significantly, students indicated willingness to purchase their own HHPC's at this point (item 13). All students felt the TI-59 was beneficial (item 12); the average numerical factor indicates a self-rated increase in ability of 60%, up from the 34% mean reported two quarters earlier. This increase is highly significant (paired t-test). Students were least enthusiastic about use of the HHPC for personal problem solving (item 10); in this case their response was essentially neutral. Generally, opinions were more optimistic on the current questionnaire than those given two quarters earlier. There were significantly more moves toward optimism than toward pessimism for items 1, 3, 4, 5, 6, 8, 9, 11, 13; for the remaining items there were not significant trends in either direction. On an individual basis, of the 16 individuals for which we have paired responses (earlier-to-present questionnaire), 12 were generally more optimisitic now whereas 2 had become somewhat more pessimistic. Comments on items 14, 15, 16 generally concerned specific features of the TI-59, rather than notions applicable to the HHPC concept itself.

Sub-experiment 6 (instructor's comments).

Conclusions: I believe the use of the HHPC in statistics courses has great potential for improving the quality of our graduates. In order to follow this approach, it is imperative that all students in the course have HHPC's in their possession. In early courses (say during the first three quarters), it is highly desirable that the students have a common make and model of HHPC, so that programming "tricks" can be taught as necessary. Implementation of instruction on the HHPC during the first quarter is desirable. The major impact of the formal use of HHPC's in statistics courses is the flexibility it generates. The variety of topics and methods of instruction open to the instructor increase tremendously when students are all HHPC equipped. In addition, this approach generates many opportunities for touching on ideas, procedures and topics covered in other courses, thus enhancing the interaction among courses and reinforcing the materials learned by the students.

Formal use of HHPC's in classes would provide several advantages:

1. our education process will be more efficient (students will learn more per hour of effort);
2. our education process will be more relevant to DoD needs;
3. our students will be more capable analysts.

4. Recommendations

The present experiment suggests students and instructors respond enthusiastically to the formal use of HHPC's in appropriate courses. The cost of acquisition of HHPC's (such as the TI-59) is insignificant in comparison with other costs of the educational system. Surely, even if there is only a small enhancement in quality of education, such acquisition has very substantial cost-effectiveness. I recommend NPS undertake vigorous search for funds to accommodate acquisition of HHPC's for students in appropriate curricula on an ongoing basis, so students may retain "their" HHPC's when they return to the fleet. The results of the present experiment suggest this should be a high priority goal at NPS. It is difficult to imagine how else one might hope to gain so much for so little.

Acknowledgment: The author wishes to thank Dean W. M. Woods, Professor M. G. Sovereign and Professor P. W. Zehna for their assistance and support in this experiment. Most of the prepared programs used in this experiment were written by Professor Zehna.

5. Appendix.

This appendix contains copies of the exams and other materials used in the various sub-experiments. Tally summaries are shown on the questionnaire copy.

SUB-EXPERIMENT 1

BARR 11/7/79 PS 3303 LAB 5 NAME _____
40 minutes

1. A die is rolled 120 times. If 25 times a 3 is obtained, does this cause us to doubt that this is a honest die? ($\alpha = .05$).

2. A car manufacturer claims that its cars use on the average 5.5 gallons of gasoline for each 100 miles. A salesman tests 35 cars and finds they average 5.65 gallons for each 100 miles, with a standard deviation of .35 gallons. Do these results cast doubt on the claims of the company? ($\alpha = .01$).

3. Two types of electric bulbs are observed as to length of life, and the following data result:

	Type 1	Type 2
number in sample	46	64
mean of sample	1,070	1,041
sum of squares of error	21,000	23,200

Are the mean lives significantly different? ($\alpha = .1$).

4. The standard deviation in lines of code for 10 programs in department A was 26.1; that for 17 programs in department B was 30.7. What is the significance of this difference?

5. Below are figures for protein tests of the same variety of wheat grown in two districts. If these are the only figures available, test whether or not there is a significant difference between the average proteins for the two districts ($\alpha = .05$).

District 1: 12.6, 13.4, 11.9, 12.8, 13.0
District 2: 13.1, 13.4, 12.8, 13.5, 13.3, 12.7, 12.4.

6. Two types of apple trees are planted in each of 8 orchards, and (several years later) sugar content is measured in the apples. Is there a difference in sugar content for the two types? ($\alpha = .13$).

Orchard	1	2	3	4	5	6	7	8
Type 1 apple	13	14	19	10	15	14	12	11
Type 2 apple	12	16	17	9	16	12	10	8

SUB-EXPERIMENT 1

BARR 11/7/79 PS 3303 LAB 5 NAME _____

1. From experience it is known that 20% of a certain kind of seed germinate. If in an experiment 60 out of 400 seeds germinate, is this considered a significantly poor germination? ($\alpha = .1\%$).

2. The height of adults in a certain town has a mean of 65.42 inches with a standard deviation of 2.32 inches. A sample of 144 adults living in the slum district is found to have mean height of 64.82 inches. Does this indicate that the slum residents have significantly retarded growth? ($\alpha = .05$).

3. The following data pertain to growth of wheat under two treatments, A and B:

	Treatment A	Treatment B
number of stalks	44	36
mean height	16.6	14.1
sum of squares of error	167.52	159.89

Is there a significant difference between these two means? ($\alpha = .10$)

4. The standard deviation of heigths of 16 men in city A was found to be 1.62 inches; that of 23 men in city B was 2.02 inches. What is the significance of this difference?

5. A cigarette manufacturer tests tobaccos of two different brands for nicotine content and obtains the following (in milligrams):

Brand A: 24, 20, 25, 22, 23

Brand B: 27, 28, 25, 29, 26.

Do these results indicate there is a difference in mean nicotine content for the two brands? ($\alpha = .05$)

6. 10 plots are split and half planted to variety A the other to B. The yields are shown below. Is there a difference in mean yields? ($\alpha = .13$).

plot	1	2	3	4	5	6	7	8	9	10
variety A	49	58	53	60	45	49	66	55	44	52
variety B	47	57	49	57	58	44	67	52	42	53

SUB-EXPERIMENT 2

BARR 12/5/79 PS 3303 QUIZ 7 NAME _____

1. Estimate the regression of Y on X using the data below.

x	45	42	56	48	42	35	58	40	39	50
y	6.53	6.30	9.52	7.50	6.99	5.90	9.49	6.20	6.55	8.72

2. Estimate the variance of Y, given X = 50.

3. Find a 95% confidence interval for the slope of the regression line.

4. Test $H_0:\beta_0 = 0$ vs $H_1:\beta \neq 0$ ($\alpha = .10$).

SUB-EXPERIMENT 3

BARR 11/15/79 PS 3303 QUIZ 6 NAME _____

A manufacturer of hand calculators has three different assembly plants A, B and C. The proportion of defective calculators assembled by these plants to date are recorded as .01, .02 and .04, respectively. Plant A assembles 50% of the calculators while Plants B and C respectively assemble 30% and 20%. A customer purchases a calculator and finds it to be defective (Event "E").

a) What is the probability of E occurring?

b) What is the conditional probability that the defective calculator was assembled at plant A? Plant B? Plant C?

SUB-EXPERIMENT #4

BARR
OA 3303 FINAL EXAM NAME _____

True False

____ ____ 1. A confidence interval is said to be "best" provided its use gives full credit on an exam question.

____ ____ 2. A random interval may be of fixed (nonrandom) width.

____ ____ 3. "Confidence" is just another word for "probability."

____ ____ 4. Of the five order statistics of a random sample, from a $U(0,1)$ population, the middle one, $X_{(3)}$ has the largest variance.

____ ____ 5. The generalized likelihood ratio test provides a best test of its size for a simple null against a simple alternate hypothesis.

____ ____ 6. Suppose $X \sim b(1,p)$ where $0 \leq p \leq 1/2$, and we have a random sample of size n on X. Then $1/n \cdot \sum_{i=1}^{n} X_i = \bar{X}$ is a MLE for p.

____ ____ 7. In a random sample of size 20 from a $b(1,p)$ distribution, we find $\bar{x} = .4$. A 90% confidence interval for p is $(.27, .51)$.

____ ____ 8. If (X,Y) have a bivariate distribution, the conditional variance of Y, given $X = x$, is a constant not depending on x.

____ ____ 9. The estimators for slope and intercept, based on a common data set, cannot be independent.

____ ____ 10. F_n is a consistent estimator of F.

II. (30)

Two hundred people in a Western city were chosen at random and asked whether or not they thought the fire department was satisfactory. One hundred said satisfactory and 100 said unsatisfactory. Just after the poll, a tragic fire took place. Following the fire, the observer then went to the same 200 people and repeated the question. This time 90 said satisfactory and 110 said unsatisfactory. The observer set up the following 2 × 2 table:

	Sat	Unsat
Before	100	100
After	90	110

He computes χ^2 as 1.0. He then concluded that the apparently decreased confidence in the fire department was not statistically significant.

A colleague told him that this analysis was incorrect and that the table should have been set up in a different way (for which, fortunately, the necessary facts were available), namely

		Before	
		Sat	Unsat
After	Sat	70	20
	Unsat	30	80

The χ^2 computed for this table is 50.5, a result apparently of considerable statistical significance.

When you are asked about the problem, you point out that neither analysis is correct. Discuss briefly, but carefully, and carry out a correct test.

III. (15) Let $X_1, X_2, \ldots, X_5$ be a random sample of size 5 from a $N(\mu, \sigma^2)$ population, where both μ and σ^2 are unknown.

(a) State a random interval which includes μ with probability .99.

(b) Suppose the values of the x's were: 0, 2, -1, 1, 3. Give a 99% confidence interval for μ.

(c) Give a 99% confidence interval for σ^2.

IV. (20) The following (x,y) pairs were observed in a simple linear regression situation: (1,-1), (2,-3), (0,-1), (1,0), (5,-4), (-2,4).

(a) State the assumptions of the model for the regression of Y on x.

(b) Calculate $\hat{\beta}$.

(c) Calculate $\hat{\sigma}^2$.

(d) Test $H_0: \beta_1 = 0$.

(e) Find a 90% confidence interval for β_0.

V. (15) A computer model has been designed to simulate the localization of an underwater target. Four different sonobuoy patterns were investigated, with each pattern being used 4 times (4 independent simulation runs for each pattern). The time required (in minutes) to localize the target was observed for each run, giving the numbers in the table below:

Pattern number			
1	2	3	4
246	246	251	254
244	235	247	246
237	235	237	244
233	232	237	236

Assuming that the time to localize the target is a normal random variable with the same variance, no matter which pattern is used, would you conclude that the expected time to localize the target is the same for all patterns?

SUB-EXPERIMENT #4

BARR
OA 3303

FINAL EXAM NAME _____

True False

____ ____ 1. A confidence interval is said to be "best" provided its use gives full credit on an exam question.

____ ____ 2. A random interval may be of fixed (nonrandom) width.

____ ____ 3. "Confidence" is just another word for "probability."

____ ____ 4. Of the five order statistics of a random sample, from a $U(0,1)$ population, the middle one, $X_{(3)}$ has the largest variance.

____ ____ 5. The generalized likelihood ratio test provides a best test of its size for a simple null against a simple alternate hypothesis

____ ____ 6. Suppose $X \sim b(1,p)$ where $0 \leq p \leq 1/2$, and we have a random sample of size n on X. Then $1/n \cdot \sum_{i=1}^{n} X_i = \bar{X}$ is a MLE for p.

____ ____ 7. In a random sample of size 20 from a $b(1,p)$ distribution, we find $\bar{x} = .4$. A 90% confidence interval for p is $(.27, .51)$.

____ ____ 8. If (X,Y) have a bivariate distribution, the conditional variance of Y, given $X = x$, is a constant not depending on x.

____ ____ 9. The estimators for slope and intercept, based on a common data set, cannot be independent.

____ ____ 10. F_n is a consistent estimator of F.

II. (30)

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A colleague told him that this analysis was incorrect and that the table should have been set up in a different way (for which, fortunately, the necessary facts were available), namely

		Before	
		Sat	Unsat
After	Sat	70	20
	Unsat	30	80

The χ^2 computed for this table is 50.5, a result apparently of considerable statistical significance.

When you are asked about the problem, you point out that neither analysis is correct. Discuss briefly, but carefully, and carry out a correct test.

III. (15) Suppose you have only a regression program available. Describe precisely how you could use several runs with the program to accomplish a one-way analysis of variance.

IV. (20) For a simple linear regression with $n = 7$, $\bar{x} = 5$, $\bar{y} = 7$, $\Sigma (x_i - \bar{x})^2 = 28$, $\Sigma (y_i - \bar{y})^2 = 102$, $\Sigma (x_i - \bar{x})(y_i - \bar{y}) = 53$.

(a) Determine a point estimate of the response $Y(10)$ which would be observed with x set at 10.

(b) Give a 90% regression interval for $Y(10)$.

V. (15) Perform a size .05 K-S Goodness-of-Fit test of the data below to a $U(0,2)$ distributions:

1.1, 0,5, 1.3, 1.0, 1.7, 1.1, 0.9, 0.7, 1.9, 0.7.

SUB-EXPERIMENT 5

1. Overall, how much did the TI-59 help you in achieving success in this course?

Helped Tremendously	1	2	3	4	5	Did Not Help At All
	9	6	4	2	0*	

$\bar{x} = 2.0$

$s = 1.0$

-:6 (number decreasing from before)
0:7 (number staying same as before)
+:3 (number increasing from before)

2. To what extent, if any, did the TI-59 distract from your learning the material in this course?

Did Not Distract At All	1	2	3	4	5	Distracted A Great Deal
	8	10	1	2	0	

$\bar{x} = 1.9$

$s = .9$

-:6
0:2
+:8

3. To what extent did the TI-59 help you in making numerical calculations?

Helped Tremendously	1	2	3	4	5	Did Not Help At All
	18	3	0	0	0	

$\bar{x} = 1.1$

$s = .3$

-:6
0:10
+:0

4. To what extent did the TI-59 help you to increase your understanding of the basic objectives of this course?

Helped Tremendously	1	2	3	4	5	Did Not Help At All
	1	6	9	4	1	

$\bar{x} = 2.9$

$s = .9$

-:9
0:5
+:2

*Script typed numbers are frequencies of responses on the recently administered questionnaire. $\bar{x}$ and s are the sample mean and standard deviation, respectively.

5. Frequently, problems have "nice," predictable answers (e.g., $4/3\pi$), which may be reinforcing. With calculators such as the TI-59, it is possible for the instructor to assign problems that have unpredictable answers. Do you feel this distracts from your learning the material better?

Does Not Distract At All	1	2	3	4	5	Distracts A Great Deal
	10	7	2	2	0	

$\bar{x} = 1.8$ $\quad$ $\sigma = 1.0$

-:7
0:7
+:2

6. Do you consider data entry to be a serious problem in the use of the TI-59?

Data entry is <u>not</u> a serious problem	1	2	3	4	5	Data entry <u>is</u> a serious problem
	5	6	4	5	1	

$\bar{x} = 2.6$ $\quad$ $\sigma = 1.2$

-:4
0:5
+:7

7. Did using the TI-59 affect your anxiety in testing situations?

INCREASED it significantly	1	2	3	4	5	DECREASED it significantly
	2	3	8	6	2	

$\bar{x} = 3.1$ $\quad$ $\sigma = 1.1$

-:4
0:7
+:5

8. How clear were the instructions for entering data and outputting results?

Extremely Clear	1	2	3	4	5	Muddy or Nonexistent
	4	5	5	7	0	

$\bar{x} = 2.7$ $\quad$ $\sigma = 1.1$

-:10
0: 5
+:.1

9. To what extent did you use the TI-59 for field work or problem solving related to your education here, but not directly related to your class work this quarter?

Used it a Great Deal						Did Not Use It At All
	1	2	3	4	5	
	3	11	3	5	0	

$\bar{x} = 2.5$

$s = 1.0$

-:9
0:4
+:2

10. To what extent did you use the TI-59 for personal problem solving such as depreciation schedules, interest rate tables, etc.?

Used It a Great Deal						Did Not Use It At All
	1	2	3	4	5	
	3	4	2	10	2	

$\bar{x} = 3.2$

$s + 1.3$

-:8
0:2
+:6

11. How much did the use of the TI-59 help you achieve success in other courses?

Helped a Great Deal						Did Not Help At All
	1	2	3	4	5	
	4	9	2	3	3	

$\bar{x} = 2.6$

$s = 1.3$

-:10
0: 3
+: 3

12. If you had to estimate in a numerical sense how much you have benefited from or been hindered by the use of the TI-59, please estimate the percentage it has helped or hindered. For example, if you feel it has increased your ability to solve problems by a factor of one-tenth, enter 10%.

Overall, the TI-59 has [HELPED] HINDERED (circle one) my progress in the program. The factor is: $\bar{x} = 60; s = 21$

13. If you had to return your TI-59 today, would you go out and buy one for yourself?

Definite YES	1	2	3	4	5	Definitely NOT
	11	7	1	0	0	

$\bar{x} = 1.4$

$s = .5$

-: 5
0: 10
+: 0

14. Please state the two things you <u>like</u> <u>most</u> about using the TI-59.

15. Please state the two things you <u>like</u> <u>least</u> about using the TI-59.

16. Other comments, suggestions, remarks.

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Report on an experiment on formal use of hand held programmable calculators in statistics courses.